Larry Peck
Kurt Irgolic
Rod O'Connor
Texas A&M University
College Station, TX 77843

Bicarbonate in Alka-Seltzer®

A general chemistry experiment

Examination of many general chemistry lab manuals in use today reveals that if an experiment that involves gas law calculations is included, it is almost without exception one of the following types: (1) reaction of a metal and acid with subsequent measurement of the hydrogen gas produced; (2) thermal decomposition of potassium chlorate with subsequent measurement of the oxygen produced (or, in a similar experiment, reaction of sodium nitrate and sulfamic acid to yield nitrogen); (3) expansion or compression of gaseous samples as they are subjected to a variety of pressures and temperatures; or (4) determination of the molar mass of a volatile liquid by vapor density measurement. In this report a different experiment dealing with gas law calculations is described. The experiment utilizes Alka-Seltzer® as a source of carbon dioxide.

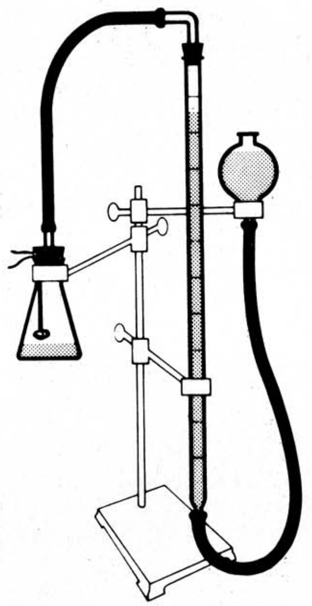
In the experiment described below students generate carbon dioxide in an apparatus similar to that often used for the decomposition of potassium chlorate. Dilute acid is used instead of heat to bring about the reaction. By means of calculations based on the volume of carbon dioxide collected the students determine the amount of bicarbonate ion or sodium bicarbonate contained in the original tablet. This experiment not only develops (as do most of the other experiments) the students' appreciation of the utility of the general gas law, Dalton's law of partial pressures, stoichiometry, etc., but also it (perhaps even more importantly) contains "relevance" which most other gas law experiments seem to lack. From the administrative standpoint, this experiment utilizes inexpensive reagents and (at least in our case) equipment that was already available to the laboratory course. We have used this experiment for several years[1,2] and it has been one of our most popular experiments for both the students and the instructors.

Procedure

Each pair of students uses half an Alka-Seltzer® tablet and practices breaking off small fragments that weigh between 0.2 and 0.3 g. In subsequent steps it is important that the students consistently be able to obtain tablet fragments that weigh no more than 0.3 g and that the students obtain and weigh the fragments without coming in direct contact with the tablets or the fragments. The fragments produced at this point are added to 125 ml of water containing 2 ml of 6 *M* HCl. The resulting CO_2-saturated solution is used to fill the leveling bulb and buret of the apparatus shown in the figure. It is assumed throughout the remaining portions of the experiment that no further absorption (or release) of CO_2 will occur by the solution used to fill the leveling bulb and buret.

With the buret and leveling bulb filled, the system is checked for air leaks by closing the system and raising and lowering the leveling bulb. (Some students may need to be reminded of Boyle's law at this point.) If leaks are detected, the various connections will need to be moistened and tightened. Once the system has been determined to be gas-tight, it is opened and 5 ml of 6 *M* HCl and a tablet fragment (0.2–0.3 g) are added to the Erlenmeyer flask (these are shown in the above figure). The tablet fragment is suspended by a fine thread and neither the acid solution nor the tablet is allowed to come into contact with the upper walls of the container. The system is checked again for air leaks.

The stopper in the Erlenmeyer flask is loosened and the level of solution in the buret is adjusted to near zero. The system is closed, the level in the leveling bulb is made to match that in the buret, and the volume of liquid in the buret is read and recorded. The reaction is initiated by loosening the clamp holding the Erlenmeyer flask and tilting the flask until the tablet is immersed in the acid.



Apparatus for measuring gas generated.

After the evolution of CO_2 ceases, the levels in the bulb and buret are again matched and the liquid volume in the buret is read and recorded.

Having determined the mass of a tablet, the mass of sample used, room temperature, the temperature of the solution in the buret (preferably the same as room temperature), the current barometric pressure, and the volume of gas generated, the student can use these data along with the general gas law equation, Dalton's law of partial pressures, and the vapor pressure of water at the temperature of the solution in the leveling bulb to calculate the moles of carbon dioxide generated, the percent by mass of bicarbonate in the tablet, etc.

A small correction is usually used to compensate for the carbon dioxide that dissolves in the acidic solution in the Erlenmeyer flask. We treat this correction factor as a constant that depends only upon the volume of acid present. The value of 0.80 ml of CO_2 gas at 25°C and 760 torr per milliliter of acid is used. The students convert this correction to a volume at the temperature equal to that of the solution in the buret and at a pressure equal to the partial pressure of the gaseous CO_2. It is then added to the volume determined by the buret. [Perhaps the solution could be saturated by the use of dry ice and, thus, avoid the need for this correction.]

Since it only takes about 10 min to empty the Erlenmeyer flask, rinse and wipe out the residual water droplets, and add a new aliquot of 6 *M* HCl and a new weighed fragment of tablet, we recommend that the students repeat the experiment several times. All runs in which the tablet touched the wall prematurely or the tablet was touched with the fingers or some other questionable happening occurred are recorded, marked as doubtful determinations, and not used in subsequent calculations. All students are required to obtain at least four usable determinations.

Discussion

Our students calculate the percent bicarbonate ion by mass and the average and average deviation of their results. Presently there are three Alka-Seltzer® preparations on the market and typical student data are illustrated by the following table.

Student Data

	Alka-Seltzer® "with specially buffered aspirin"	Alka-Seltzer® "special antacid formula" [without aspirin]	Alka-Seltzer Plus® "cold medicine"
mass of tablet	3.3763 g	2.3459 g	3.1271 g
percent HCO_3^- by mass	39.4 ± 0.7%	38.5 ± 0.9%	34.6 ± 0.8%

[1] Irgolic, K., and O'Connor, R., "Fundamentals of Chemistry in the Laboratory," Harper & Row, Publishers, N.Y., **1974**, pp. 91–104

[2] Irgolic, K., Peck, L., and O'Connor, R., "Fundamentals of Chemistry in the Laboratory," 2nd Ed., Harper & Row, Publishers, N.Y., **1977**, pp. 87–98

Student results typically agree within two percent with the labeled content for the antacid products (both with and without aspirin). The amount of bicarbonate present in Alka-Seltzer Plus® has not been revealed by the manufacturer. The student accuracy perhaps could be improved if the tablets were uniformly dried, etc. However, it is our feeling that any discrepancy with labeled content is more than compensated for by the increased relevance gained by letting the students use the product as obtained in its original package. One could introduce additional variety into this experiment by using tablets purchased at different times or from different sources. However, we have found that the three types of Alka-Seltzer® give sufficient variety, and we try not to introduce different "ages" of the same preparation into a given lab section.

This is a very economical experiment. Even when the most expensive preparation is used (the Alka-Seltzer Plus®), the cost for consumables for this experiment is only about 10 cents per student if towels and distilled water are not included and if each student is limited to one tablet.

Acknowledgment

The authors wish to thank Miles Laboratories, Inc. Our students enjoyed reading about the history of Alka-Seltzer®.